APPENDIX C

Survey of Chlorinated Hydrocarbons and Metals
in
Sediments of the Los Cerritos Channel Estuary

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Survey of Chlorinated Hydrocarbons and Metals in Sediments of the Los Cerritos Channel Estuary

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INTRODUCTION

This survey was designed primarily to investigate the distribution of chlordane in sediments within the Los Cerritos Channel. Other chlorinated hydrocarbons and metals were incorporated in the survey to address multiple issues.

Chlordane in sediments is cited as one of the constituents causing impairment in the Los Cerritos Channel. Chlordane belongs to a group of chemicals sometimes referred to the as the "dirty dozen" which are classified as persistent organic pollutants (POPs). In addition to chlordane, POPs include aldrin, dichlorodiphenyl-trichloroethane (DDT), dieldrin, endrin, heptachlor, hexachlorbenzene, mirex, polychlorinated biphenyls (PCB), polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and toxaphene. All these chemicals were banned worldwide in 2001 as part of the Stockholm Convention.

Chlordane first came into use in 1945. By 1983, use of chlordane in the United States was restricted to applications involving the control of underground termites. All commercial uses of chlordane were eliminated in 1988.

Technical chlordane is a complex mixture of approximately 140 compounds. The National Oceanic and Atmospheric Administration (NOAA) considers seven compounds as representative of the major components of technical chlordane. These include alpha-chlordane, gamma-chlordane, cis-nonachlor, trans-nonachlor, heptachlor, heptachlor epoxide and oxychlordane. Note that heptachlor was also used independently as a termiticide. Due to the complexity of technical chlordane, different studies have tended to measure different subsets of these compounds to represent chlordane in the environment.

Sampling for chlordane in Los Cerritos Channel has been performed twice since 1994. A Bay Protection and Toxics Cleanup Program (BCTCP) study used the summation of five compounds (alpha- and gamma-chlordane, oxychlordane, and cis- and trans-nonachlor) as a measure of "total chlordane" (Andersen et. al. 1998). The more recent SCCWRP Bight '03 study measured just alpha- and gamma-chlordane (Schiff, Maruya and Christenson, 2006). An understanding of these differences is important in comparing the results of different studies, as well as when comparing data to reference data sets such as those used to develop the NOAA Effects Range Low (ERL) and Effects Range Median (ERM).

The BPTCP report and sediment data obtained primarily from dredged material evaluation studies were reportedly used to place Los Cerritos Channel on the 303(d) list. The BCTCP collected additional data from one site near the location where the Los Cerritos Wetlands are connected to the channel. Data were collected in February 1994. This study indicated that concentrations of chlordane were approximately equal to the ERM of 6 ng/g.

Additional sampling was conducted at three sites in the Los Cerritos Channel as part of the Bight '03 studies. Concentrations of chlordane (alpha-chlordane and gamma-chlordane) were reported to progressively increase from 1.7 ng/g near the BPTCP sampling point to 3.2 ng/g near the cooling water intake for the power plant and 12 ng/g just north of the Seventh St. Bridge.

METHODS AND MATERIALS

This survey was designed to provide a contemporary baseline for chlordane in sediments of the Los Cerritos Channel Estuary. It used an adaptive approach that utilized field sampling results to develop subsequent sampling plans to isolate source areas. The specific objectives of this program are to:

- Sample targeted organochlorine compounds (primarily those associated with chlordane), metals, total organic carbon and particle size in sediment from each site.
- Utilize the results of the initial survey to determine if further investigation is warranted.

A total of six sites (LCE1 through LCE6) were selected in order to provide spatial coverage of the estuary and to resample at sites sampled by the BPTCP and Bight '03 studies (Figure 1; Table 1). LCE1 is located at the northern reach of the estuary near the Atherton St. Bridge. LCE2 is located approximate 0.5 miles downstream, near the Anaheim St. Bridge (Field Duplicate LCE7 was also collected at this location). LCE3 (Bight '03 station 4636) is located near the Seventh St. Bridge downstream from the point where Bouton Creek enters the estuary. LCE4 is located another 0.4 miles downstream between the Seventh St. and Loynes Drive Bridges. LCE5 (Bight '03 station 4118) is located in the channel leading to the water intake for the AES power plant in Alamitos Bay. The final station, LCE6 (Bight '03 station 4456 and BPTCP 44011) is located near the point where the Los Cerritos Wetlands enter the main channel.

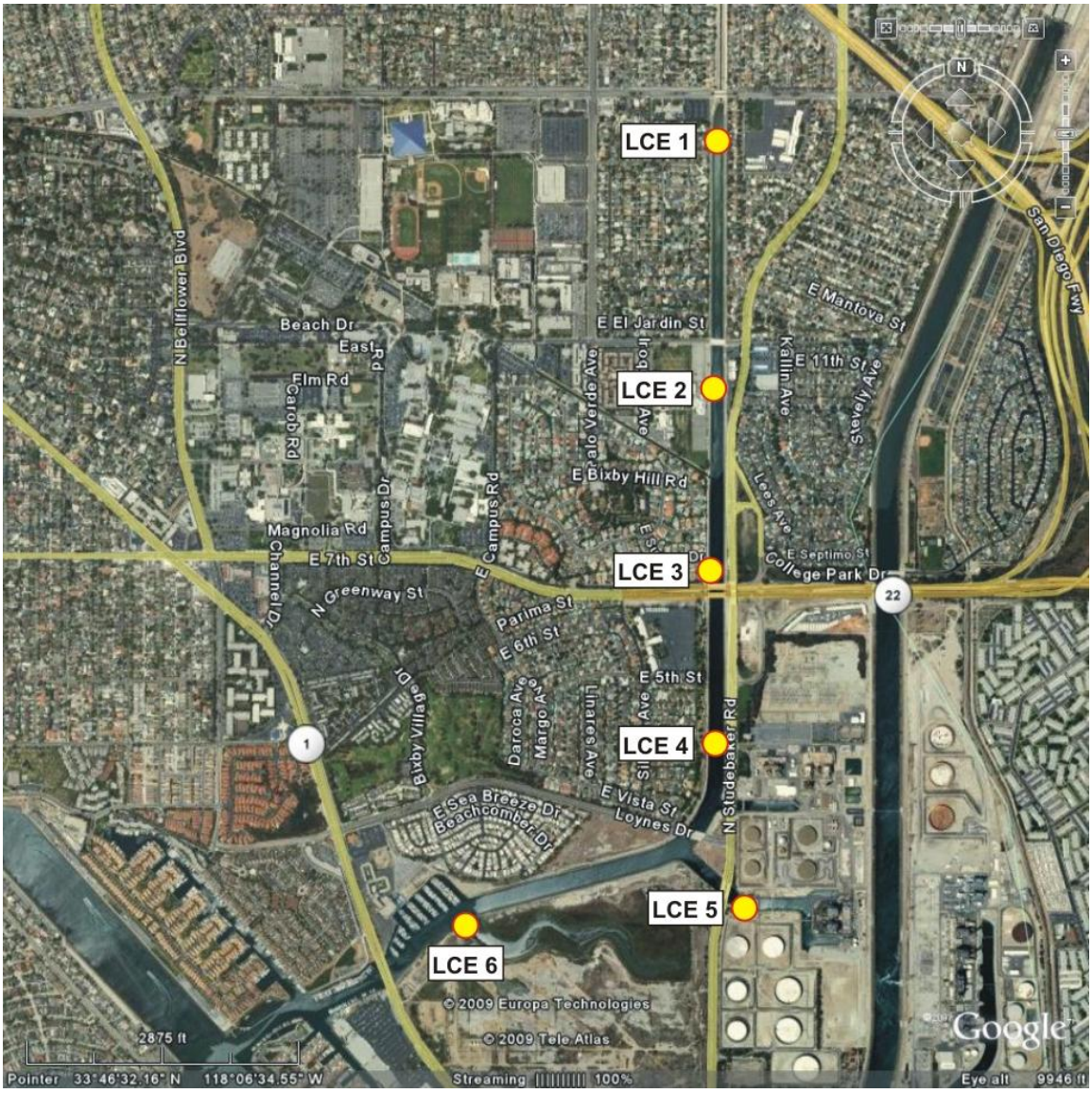


Figure 1. Location of Sediment Sampling Sites in the Los Cerritos Channel Estuary.

SAMPLING PROCEDURES

General procedures including equipment cleaning, field sampling, chemical analysis and both field and laboratory quality assurance/quality control (QAQC) are provided in the following sections. Sampling procedures for the sediment sampling program are based on those recommended by the United Stated Geological Survey (USGS) National Water Quality Assessment Program (NAWQA).

Two types of sediment sampling equipment were prepared to assure that sediment could be sampled over a range of field conditions. Stainless steel coring tubes were intended to be the primary sampling method, since sets of materials could be prepared in advance for each sampling location. Having site-specific coring tubes prepared can avoid the need to clean equipment between sites. As backup, a stainless steel Ponar Grab was also prepared, along with equipment to clean the grab between sites.

All sediment sampling equipment was prepared in the laboratory a minimum of four days prior to sampling. Sampling equipment included:

- 1.75' x 4" diameter stainless steel collection tubes
- 4" stainless steel cutting heads
- Stainless steel core catchers
- 6" x 6" Petite Ponar Grab (316 stainless steel)
- Stainless steel sampling spoons
- Wash bottles and storage containers for deionized water
- Wash bottles for hydrochloric acid (HCL) and methanol
- 500 milliliter, wide mouth glass sample containers

Cleaning methods followed protocols adapted from the NOAA National Status and Trends Program. Prior to sampling, all equipment was thoroughly cleaned. Equipment was soaked (fully immersed) for three days in 2% Micro® solution and deionized water. Equipment was then rinsed three times in deionized water and let dry in a clean place. Equipment was rinsed with a 1.0% solution of HCL, followed by a rinse with deionized water to eliminate the acid. A rinse was then conducted with methanol, followed by another set of three rinses with deionized water. All equipment was then allowed to dry in a clean place.

The cleaned Ponar Grab, coring tubes and sampling spoons were wrapped in aluminum foil until used in the field. All other equipment was stored in clean Ziploc™ bags until deployment in the field.

Final coordinates for sediment sampling were determined in the field using a handheld GPS unit. Differential GPS was used at each location and was recorded in decimal degrees to five decimal places. Field log sheets were compiled for each site that recorded the sampling date, crew members' names, sampling location, narrative description of the sampling site, and the sampling method used.

Each sampling method was designed to collect the top 10 centimeters (cm) of sediment from each sample location. Due to sediment conditions in the upper portion of the estuary, both the primary and backup sampling methods were used. Each method is described below:

Stainless Steel Coring Tubes. The coring tubes were used at the locations LCE6, LCE5, LCE4 and LCE1. These coring tubes are comprised of a stainless steel cutting head, a core catcher and a collection tube. Each pre-cleaned coring tube was preassembled prior to field use. A check valve was installed in the top of the coring tube and taped in place to prevent sediment core sample from washing out and the coring tube was connected to a 10 to 15 foot aluminum push tube so that it could be advanced into the sediments from the water's surface. The coring tube was gently lowered to the bottom, so as not to disturb the surface sediments, and then either hammered or hand-pushed into the sediment until the appropriate depth (12 to 16 inches). After retrieval of the core tube, the surface water was allowed to drain off and the top 10 cm of sediment was removed from the top of the tube with a Stainless Steel spoon and placed in the sampling container.

Stainless Petite Ponar Grab. The Ponar Grab was used to collect samples from the center of the channel at locations LCE3, LCE2, and LCE7 (LCE2 field duplicate). The Ponar Grab is a self-closing sampler using a spring-loaded Pinch-Pin™ that releases when the sampler impacts the bottom and the lowering cable or line becomes slack. The top of each scoop has a removable stainless steel screen (583 micron) to allow water to flow through the sampler during descent. This lessens the frontal shock wave created by descent and reduces surface disturbance. Both screens are covered

with neoprene rubber flaps that open during descent for water flow through, and close during retrieval to prevent sample wash out. After the Ponar Grab was retrieved, the surface water was allowed to drain off, and the top 10 cm of sediment was removed from the center of the grab with a stainless steel spoon and placed in the sampling container. In order to be considered acceptable, the Ponar Grab samples were required to satisfy a set of quality criteria. Samples were rejected if the grab did not close fully, as this allows sample material to wash out, or if removal of the overlying water resulted in significant wash-out of sediment fines.

Disposable, powder-free nitrile gloves were worn while collecting and compositing samples in order to mitigate potential contamination. Gloves were changed between each sampling location to reduce the potential for cross-contamination.

All sampling equipment used at multiple locations was field cleaned between sites. The field-cleaning protocol involved 1) removal of sediments with scrub brush and either site water or deionized water; 2) scrubbing of sampling gear and compositing equipment with a 2% Micro® solution and deionized water; 3) a rinse with deionized water; 4) a triple rinse with a 1.0% solution of HCl; 5) a triple rinse with methanol; and 6) a final triple rinse with deionized water.

At the conclusion of sample processing at each sampling location, all samples was wrapped in protective material and stored on ice at 2-4 degrees centigrade (^{o}C) until delivered to the laboratory.

Pre-cleaned Stainless Coring Tubes

Analytical Methods and Reporting Limits

Analytical methods and detection limits for sediments are summarized in Tables 1 and 2. All detection limits are based upon dry weight. Project detection limits for targeted organochlorine pesticides are summarized in Table 3. All analytical data are reported down to the Method Detection Limits (MDL), with any data between the MDL and Method Reporting Limit (MRL) qualified as an estimate by use of a "J" qualifier. Analytes completely absent from the samples are reported as non-detects at the MRL.

Samples at each site location were collected in a single container for transfer to the laboratory, where they were then homogenized and sub-sampled for each of the appropriate target analytes in Table 1. All samples were maintained at 2-4 ^{o}C during storage, transport, and shipping.

Data Assessment

Bulk sediment chemical results were compared NOAA effects based screening levels (Long et. al., 1995). The NOAA screening values can be used to screen sediments for contaminant concentrations that might cause biological effects. For any given contaminant, the ERL guideline represents the 10th percentile concentration value in the NOAA database that might be expected to cause adverse biological effects and the ERM reflects the 50th percentile value in the database.

Table 1. Analytes, Methods and Holding Times for Analysis of Sediments

Analyte	Units (dry wt.)	Method	Method Reporting Limit	Holding Times
Organochlorine Pesticides				
Chlordane Compounds	ng/g	EPA 8270Cm NCI-GCMS	0.5-1.0	14 days extract
All other	ng/g	EPA8270Cm	2.0-10	40 days analysis
Particle Size	%	SM2560D	NS[1]	6 months[2]
Percent Solids	%	EPA 160.3	0.1	6 months[2]
Trace Metals				
Al and Fe	mg/Kg	EPA 6020m	5	6 months
All others	mg/Kg	EPA6020m	0.1	
TOC	%	EPA9060A	0.1	14 days

1. NS indicates that the Target Detection Limit is not specified.
2. Maximum recommended limits if samples are sealed and refrigerated during storage.

Table 2. Individual Organochlorine Pesticides, Target Method Detection Limits (MDLs), and Method Reporting Limits (MRLs).

Organochlorine Pesticides	Laboratory MDL ng/g – dry weight	Laboratory MRL ng/g – dry weight
Chlordane Compounds		
Heptachlor	0.1	0.5
Heptachlor Epoxide	0.1	0.5
gamma-Chlordane	0.1	0.5
alpha-Chlordane	0.2	1
Oxychlordane	0.1	0.5
trans-Nonachlor	0.1	0.5
cis-Nonachlor	0.1	0.5
Other Organochorine Pesticides		
2,4'-DDD	1	2
2,4'-DDE	1	2
2,4'-DDT	1	2
4,4'-DDD	1	2
4,4'-DDE	1	2
4,4'-DDT	1	2
Total DDT	1	2
Aldrin	1	2
BHC-alpha	1	2
BHC-beta	1	2
BHC-delta	1	2
BHC-gamma	1	2
DCPA (Dacthal)	5	10
Dicofol	1	2
Dieldrin	1	5
Endosulfan Sulfate	1	2
Endosulfan-I	1	2
Endosulfan-II	1	2
Endrin	1	2
Endrin Aldehyde	1	2
Endrin Ketone	1	2
Methoxychlor	1	2
Mirex	1	2
Perthane	5	10

QUALITY CONTROL

The survey incorporated quality control measures in both the field and laboratory. One field replicate sample (LCE7) was collected during the survey at location LCE2. This was submitted blind to the laboratories performing the analyses. Data quality objectives are not established for field replicates, however, replicates are recommended in this study to assess the extent of field variability since this could have a strong influence on data interpretation.

The laboratory quality control program included use of method blanks, surrogate spikes, laboratory control samples (LCS), certified reference materials (CRM) and laboratory replicates. Table 3 provides a summary of the laboratory quality control program and performance measures applied to this survey.

Table 3. Summary of Laboratory Quality Control Performance Measures and Data Quality Objectives for Measurement of Organochlorine Pesticides, TOC and Grain Size in Sediments.

QA Sample	QA Measure	Minimum Frequency	Criteria
Method Blank	**Contamination** by reagents, laboratory ware, etc.	One per batch	<MDL or <10% of lowest sample
Certified Reference Material (CRM)	**Accuracy**	One per batch	CRM specific
	Precision		RPD (if n=2) <35% RSD (if n>2) <35% RSD of last 7 CRMs <35%
Laboratory Replicates	**Precision**	One per batch	RPDs TOC <20% OP Pest <40%
Laboratory Control Samples (LCS) (required for TOC)	**Accuracy and Precision**	One per batch	Within 20-25% consensus value
Matrix Spikes (Spike and Spike Duplicate)	**Accuracy**	One per batch	% Recoveries TOC 85-115% OC Pest 30-150%

1. MDL=Method Detection Limit; RPD=Relative Percent Difference; RSD=Relative Standard Deviation

RESULTS AND DISCUSSION

All sampling was completed on May 14, 2009. A summary of the key field sampling information is provided in Table 4.

Table 4. Summary of Field Sampling Record and Sample Identification Information.

Site ID	Sample ID	NAD83		Water Depth (ft)	Sample Time May 14, 2009	Sampling Method
		Latitude	Longitude			
LCE1	LCE1-090514	33.78722	118.10364	7.5	15:47	Core Sample
LCE2	LCE2-090514	33.78014	118.10367	7.0	17:27	Ponar Grab
LCE3	LCE3-090514	33.77486	118.10367	11.0	14:58	Ponar Grab
LCE4	LCE4-090514	33.76967	118.10372	9.2	13:41	Core Sample
LCE5	LCE5-090514	33.76539	118.10297	12.0	12:24	Core Sample
LCE6	LCE6-090514	33.76494	118.11253	9.3	11:38	Core Sample
LCE 7*	LCE7-090514	33.78014	118.10369	7.0	17:47	Ponar Grab

* Field Duplicate for Site LCE2

QUALITY CONTROL ASSESSMENT

This special sediment survey generated 378 sediment sample results not including calculated values such as Total DDT, total PCBs, etc. and another 354 quality control records (Table 5 Generally the results were well within the appropriate ranges and limits including all Blanks (BLK), Blank Spikes (BS), Matrix Spikes (MS) were in proper QC ranges. Any significant exceptions and any resulting data qualifications are presented and discussed.

Table 5. Summary of Counts of Quality Control Measures for Each Class of Analytes.

Analytical Method	BLK	BS	DUP	MS	SRM	SURR	Totals
Chlorinated Pesticides	30	60	30	60		52	232
Conventionals	2	2	2				6
Total Metals	22	44	22		28		116
Totals	**54**	**106**	**54**	**60**	**28**	**52**	**354**

The only quality control measures documented to be outside of the project control limits were laboratory duplicates for two DDT compounds and one of the organochlorine pesticide surrogates. All laboratory duplicates (DUP) except for two had Relative Percent Differences (RPDs) reported below the acceptable range of 30% and the absolute difference between the values is below the reporting limit. The laboratory duplicate quality control excursions are summarized in Table 6. Consideration was given to qualifying the associated samples as estimates but after careful review of all QC records combined and the low reporting limit the values were sent forward without flagging them as estimates.

Table 6. Summary of Laboratory Replicates Requiring Extended Review.

Analyte	Description
Chlorinated Pesticides	
4,4'-DDD	Values of 5.5 and 2U ug/kg dry; RPD of 93%; Difference is >3.5 ug/kg dry; RL is 2 ug/kg dry.
4,4'-DDE	Values of 6.3 and 2.6 ug/kg dry; RPD of 83%; Difference is 3.7 ug/kg dry; RL is 2 ug/kg dry.

All chlorinated pesticide surrogates (SURR) were reported within the laboratories acceptable quality control limits except for one of the four reported for the sample LCE3. PCB112 was reported at 114% recovery with an upper control limit of 104%. This minor exceedance of a single surrogate recovery in one sample did not warrant sample qualification.

Based upon a thorough review of the laboratory and field quality control measures, all data were considered suitable for purposes of characterizing sediment quality in the Los Cerritos Channel Estuary.

FIELD OBSERVATIONS, PHYSICAL CHARACTERISTICS AND GENERAL CHEMISTRY

Sediment characteristics were very diverse in the estuary (Table 7, Table 8). There was very little evidence of sediment deposition at LCE1 in the upper portion of the Los Cerritos Channel Estuary. This site was extremely difficult to penetrate. The bottom substrate was hard, dry olive-green clay. A thin layer of green algae was found growing on the surface of this material. Particle size analysis (Figure 2) showed this material to consist of 95% silts and clays. The organic carbon content (TOC) of this sediment (Table 9) was just 10-20% of the concentrations measured at the other five sites.

Hard-packed dry clay from bottom of core at LCE1

The substrate at LCE2 was also difficult to penetrate with the coring tube. Successful cores required a penetration of approximately 8-12 inches to assure retention of the sample. As a result, sampling had to be performed with the Ponar Grab. The target sampling depth of 10 cm was not met at this site. The layer of unconsolidated sediment was only two to four cm in depth and the clay layer prevented further penetration. Repeated grab samples (six to eight replicates) had to be taken to obtain sufficient material for testing. The replicate sample was also taken at this site. Sediments at this site were mostly characterized as moderate to fine-grained sand (Tables 7 and 8, Figure 2).

Further down the estuary at LCE3, sediment was still difficult to penetrate. A core was used in the first attempt to get a sample from this site. After driving the core into the bottom substrate, the core tip was lost, resulting in a loss of the sample. The Ponar Grab was therefore used at this site as well. The layer of unconsolidated sediments was deeper but two replicate grabs were still necessary to obtain the desired sample volumes. The unconsolidated layer was in the range of six to eight cm in the vicinity of this sampling site. The surficial sediments at this location were characterized in the field as olive-green

clays with some sandy material. The particle size analysis showed material from this site to consist primarily of silts (64%) with clays (15%), making LCE3 second only to LCE1 in silts and clays. Although TOC content of the sediment from LCE3 was the second lowest of the six sites, the concentration of organic carbon (2.17%) was still nearly 20 times greater than at LCE1.

The bottom substrate at LCE4 was also difficult to penetrate but samples were still able to be collected using the core tubes after driving the tube into bottom. Sediments at this site were showing evidence of decreasing clay content and increasing proportions of silts and sands.

Sediments at both LCE5 and LCE6 were substantially easier to penetrate and sample using the stainless steel coring tubes. Both sites had less than 50% solids and the highest concentrations of TOC measured at the six locations. Sediments at LCE6, located in the Los Cerritos Estuary at the entrance to the Los Cerritos Wetlands, also were also found to contain substantial amounts of shell debris.

Table 7. Locations, Sampling Methods and Field Notes for each Site.

SAMPLING METHOD	SITE ID	FIELD OBSERVATIONS
SS CORE[1]	**LCE1**	Substrate was very hard to penetrate, a drive hammer was used to advance the coring tube. Sediment sample had a thin layer of algae growing on the surface with the rest of the sediment consisting of an olive green hard dry clay.
GRAB[2]	**LCE2**	Substrate was very hard to penetrate. The Ponar Grab was used to collect the sediment sample at this location. Sediment sample was mostly coarse sandy material with very little fines. The sample was collected by multiple grabs with the Ponar Grab.
GRAB	**LCE3**	Substrate was very hard to penetrate, a drive hammer was used to advance the coring tube. After successfully driving the core tube to the appropriate depth, the core tip was lost upon recovery, resulting in no sample. The Ponar Grab was used to collect the sediment sample at this location. Sample collected consisted of mostly clays with a little bit of sandy material was an olive green color.
SS CORE	**LCE4**	Substrate was very hard to penetrate, a drive hammer was used to advance the coring tube. Sediment sample consisted of a sandy silt black/gray clay.
SS CORE	**LCE5**	Substrate was very soft, coring tube went in easily by hand. Sediment sample was the consistency of thick pudding, dark black in color.
SS CORE	**LCE6**	Substrate was soft and easily penetrated by push the core tube in by hand. Sediment sample had numerous amounts of shells and was a soft pudding consistency with a dark black color.
GRAB	**LCE 7**	This was a field duplicate at location LCE2. Identical collection methods were used and sediments had similar characteristics to LCE2.

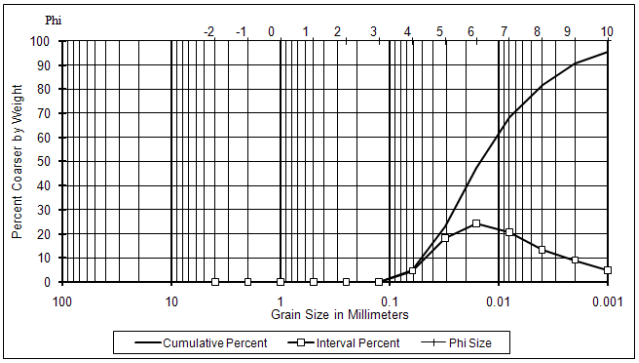
1. SS CORE = Stainless Steel Core
2. GRAB = Stainless Steel Ponar Grab

Table 8. Particle Size Distributions of Sediment from each Sampling Site.
(Percentage dry weight in each size fraction)

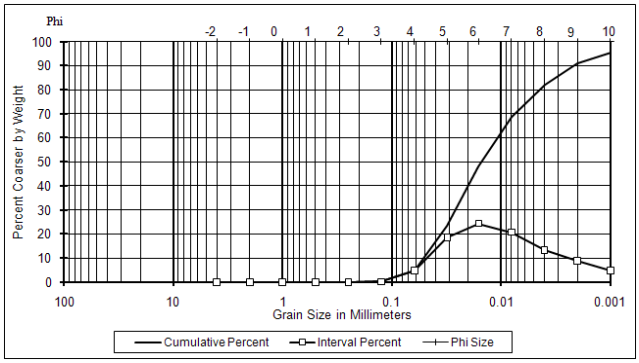
			SAMPLING SITES							
			LCE1	LCE1 (Lab Rep)	LCE2	LCE2 (Field Dup)	LCE3	LCE4	LCE5	LCE6
Phi	**Microns**	**Description**								
≤ -1	≥2000	gravel	0	0	0	0	0	0	0	0
-0.5	1410	v coarse sand	0	0	0	0	0	0	0	0
0	1000	v coarse sand	0	0	0	0	0	0	0	0
0.5	710	coarse sand	0	0	0.11	0.1	0	0	0	0
1	500	coarse sand	0	0	3.51	3.39	0	0	0	0.25
1.5	354	med sand	0	0	17.28	18.13	0	0.43	0.07	1.19
2	250	med sand	0	0	19.64	20.38	0.1	2.15	1.22	4.2
2.5	177	fine sand	0	0	10.62	9.48	1.35	6.83	5.61	10.39
3	125	fine sand	0.11	0.13	6.87	5.12	4.44	9.33	10.07	12.77
3.5	88.4	very fine sand	1.07	1.13	5.13	3.79	7.49	8.46	10.4	10.03
4	62.5	very fine sand	3.57	3.62	4.39	3.77	8.08	7.11	8.41	7.08
4.5	44.2	coarse silt	7.46	7.64	4.19	4.21	8.09	6.85	7.2	5.89
5	31.3	coarse silt	10.85	11.02	4.32	4.74	8.56	7.42	7.28	6.02
5.5	22.1	med silt	12.4	12.41	4.48	5.07	9.11	7.95	8.03	6.55
6	15.6	med silt	11.98	11.94	4.4	5.03	9.15	7.92	8.68	6.85
6.5	11.1	fine silt	11.28	11.26	4.19	4.82	9.12	7.82	9.03	7.03
7	7.8	fine silt	9.47	9.45	3.34	3.83	8.03	6.79	7.66	6.11
7.5	5.5	very fine silt	7.74	7.69	2.4	2.73	6.7	5.58	5.63	4.78
8	3.9	very fine silt	5.71	5.66	1.52	1.7	4.94	4.04	3.45	3.21
8.5	2.8	clay	5.29	5.22	1.17	1.28	4.44	3.55	2.53	2.56
9	1.95	clay	3.78	3.68	0.74	0.77	3.02	2.36	1.46	1.57
9.5	1.38	clay	2.37	2.29	0.5	0.5	1.82	1.4	0.85	0.93
10	0.98	clay	2.42	2.45	0.45	0.46	1.91	1.43	0.82	0.92
10.5	0.69	clay	2.45	2.46	0.42	0.45	1.89	1.36	0.81	0.86
11	0.49	clay	1.55	1.46	0.32	0.23	1.28	0.87	0.61	0.62
11.5	0.35	clay	0.51	0.47	0.02	0	0.49	0.33	0.18	0.19
≥12	≤0.24	clay	0	0	0	0	0	0	0	0

Table 9. Percent Solid and Total Organic Carbon in Surficial Sediment from each Site.

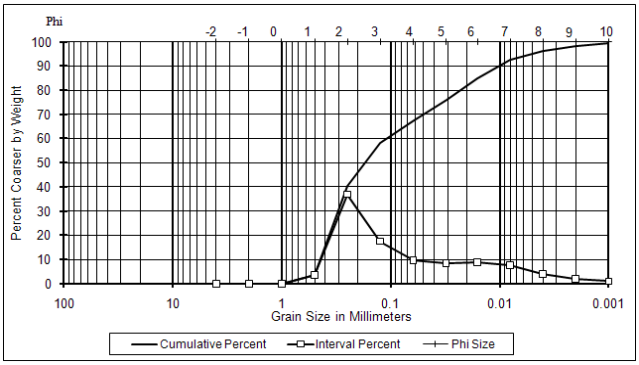
	SAMPLING SITES						
	LCE1	LCE2	LCE2 FD (LCE7)	LCE3	LCE4	LCE5	LCE6
GENERAL CHEMISTRY							
Percent Solids	**70.9**	**82.9**	**79.9**	**68.4**	**77.3**	**49.1**	**47.2**
Total Organic Carbon (%)	**0.38**	**2.24**	**2.82**	**2.17**	**2.57**	**3.14**	**3.83**



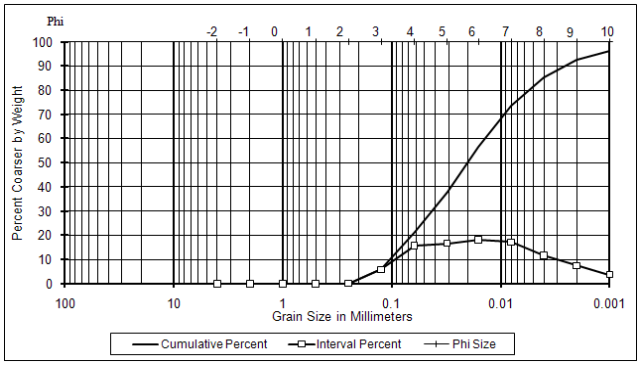
a) LCE1



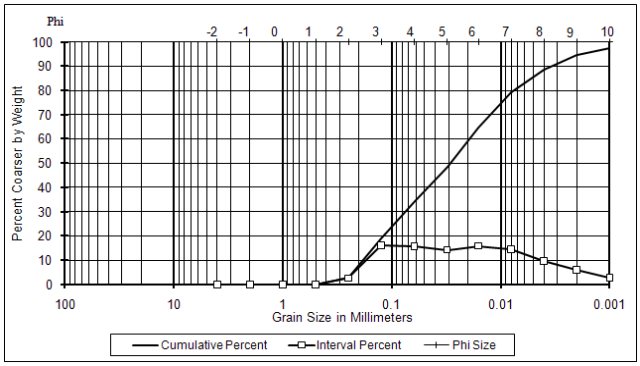
b) LCE1 (Lab Dup)



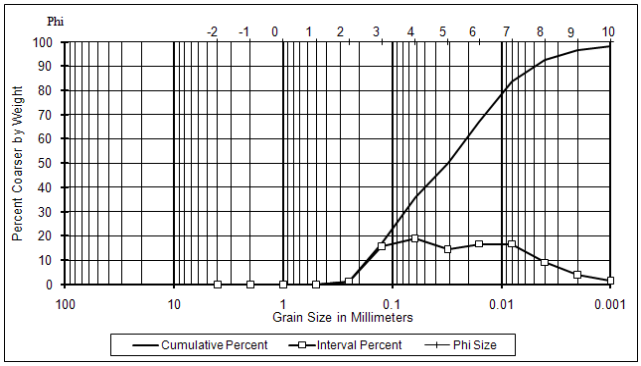
c) LCE2



d) LCE3

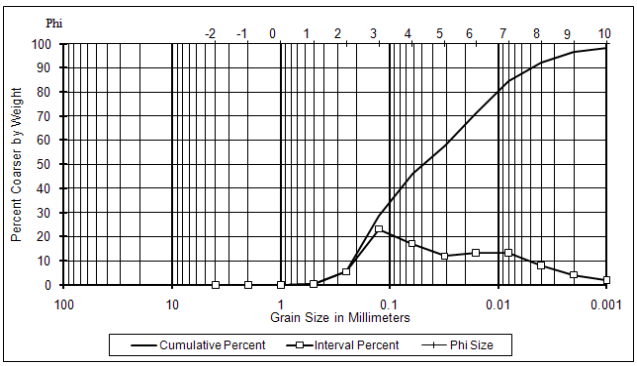


e) LCE4

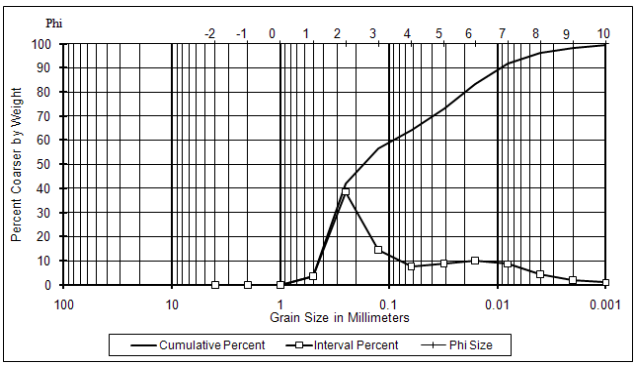


f) LCE5

Figure 2. Particle Size Distribution of Surficial Sediment at Stations LCE1 through LCE6.
(Includes laboratory and field duplicate)



g) LCE6



h) LCE7 (LCE2 Field Duplicate

Figure 2. Particle Size Distribution of Surficial Sediment at Stations LCE1 through LCE6. (Includes laboratory and field duplicate)

CHLORDANE, DDT AND OTHER ORGANOCHLORINE PESTICIDES

Four out of the seven major chlordane components were detected in sediment samples from the Los Cerritos Channel (Figure 3; Table 10). Chlordane-alpha and chlordane-gamma were the most abundant compounds with trans-nonachlor and cis-nonachlor also contributing to the totals. Heptachlor, heptachlor epoxide and oxychlordane were below MDLs in all cases. All results are presented in dry weight.

Chlordane compounds exceeded or were approximately equal to the ERM values at all sites except LCE1. Concentrations measured at LCE5 and LCE6 were roughly 4-5 times the ERM of 6 ng/g, with results of 23.4 ng/g and 28.4 ng/g, respectively.

SCCWRP's Bight '03 project measured concentrations of chlordane at three of the locations sampled in this survey. Since the Bight '03 survey only measured chlordane-alpha and chlordane-gamma, comparisons were limited to these two components (Table 11). Chlordane concentrations measured at LCE3 were less than 1/3 of the levels reported during Bight '03, when they measured 12 ng/g. Concentrations at LCE5 and LCE6, in the lower portion of the estuary, have substantially increased since Bight '03, when results of 1.7 ng/g and 3.2 ng/g were reported.

LCE6 was also sampled in 1994 as part of the Bay Protection and Toxics Control Program (Table 11). The BPTCP station designation for this site was 44011. This station was sampled in triplicate, with total chlordane results ranging from 5.2 to 6.2 ng/g.

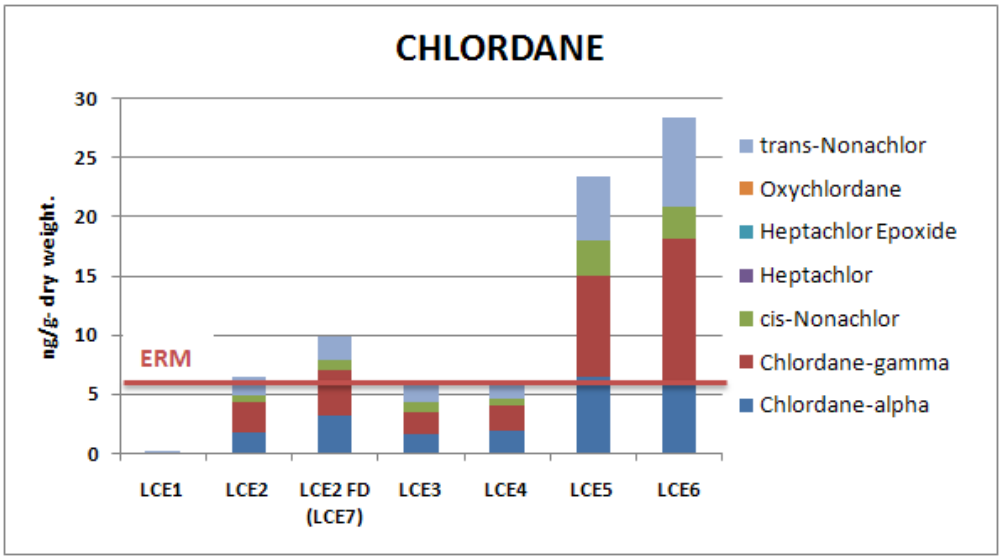


Figure 3. Breakout of the Seven Major Chlordane Compounds Measured at Each Survey Location.

The only other organochlorine compounds detected in the Los Cerritos Estuary sediments were 4,4'-DDD, 4,4'-DDE and 2,4'-DDT(Table 10). Two of these isomers, 4,4'-DDD and 2,4'-DDT, were only found at LCE3. Concentrations of 4,4'-DDD in the LCE3 sediment exceeded the ERL. The most common isomer,4,4'-DDE, was detected at all sites except LCE1. The ERL value of 1.0 ng/g was exceeded each time it was detected. Similar to chlordane, DDT compounds were found in highest concentrations at LCE5 and LCE6.

Concentrations of DDT compounds have been quite variable since first measured in 1994 as part of a BPTCP Survey. Differences in concentrations measured during the Bight '03 survey and the 2009 survey show conflicting trends with a three-fold decrease at LCE3, a three-fold increase at LCE5 and relatively stable conditions at LCE6 (Table 12). Since 1994, concentrations of total DDT in sediments at LCE6 have not decreased substantially but the composition of DDT congeners has changed.

Table 10. Chlordane, DDT and Other Organochlorine Pesticides in Surficial Sediments from Each Los Cerritos Estuary Site (2009).

	SAMPLING SITES								
	LCE1	LCE2	LCE2 FD (LCE7)	LCE3	LCE4	LCE5	LCE6	ERL	ERM
CHLORINATED PESTICIDES									
Chlordane by NCI									
Chlordane-alpha	1U	1.8	3.2	1.6	1.9	6.5	6		
Chlordane-gamma	0.1J	2.5	3.8	1.9	2.1	8.5	12.2		
cis-Nonachlor	0.5U	0.6	0.9	0.8	0.6	3.0	2.6		
Heptachlor	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U		
Heptachlor Epoxide	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U		
Oxychlordane	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U		
trans-Nonachlor	0.1J	1.5	2	1.8	1.3	5.4	7.6		
Total Chlordane	0.2J	6.4	9.9	6.1	5.9	23.4	28.4	0.5	6.0
DDT Compounds									
2,4'-DDD	2U	2U	2U	2U	2U	2U	2U		
2,4'-DDE	2U	2U	2U	2U	2U	2U	2U		
2,4'-DDT	2U	2U	2U	2.1	2U	2U	2U		
4,4'-DDD	2U	2U	2U	4.2	2U	2U	2U	2	20
4,4'-DDE	2U	4.3	5.8	3.9J	2.6	23.8	19	2.2	27
4,4'-DDT	2U	2U	2U	2UJ	2U	2U	2U	1	7
Total DDT	-	4.3	5.8	10.2	2.6	23.8	19	1.58	46.1
Other Chlorinated Pesticides									
Aldrin	2U	2U	2U	2U	2U	2U	2U		
BHC-alpha	2U	2U	2U	2U	2U	2U	2U		
BHC-beta	2U	2U	2U	2U	2U	2U	2U		
BHC-delta	2U	2U	2U	2U	2U	2U	2U		
BHC-gamma	2U	2U	2U	2U	2U	2U	2U		
DCPA (Dacthal)	10U	10U	10U	10U	10U	10U	10U		
Dicofol	2U	2U	2U	2U	2U	2U	2U		
Dieldrin	5U	5U	5U	5U	5U	5U	5U	2.2	8.0
Endosulfan Sulfate	2U	2U	2U	2U	2U	2U	2U		
Endosulfan-I	2U	2U	2U	2U	2U	2U	2U		
Endosulfan-II	2U	2U	2U	2U	2U	2U	2U		
Endrin	2U	2U	2U	2U	2U	2U	2U		
Endrin Aldehyde	2U	2U	2U	2U	2U	2U	2U		
Endrin Ketone	2U	2U	2U	2U	2U	2U	2U		
Methoxychlor	2U	2U	2U	2U	2U	2U	2U		
Mirex	2U	2U	2U	2U	2U	2U	2U		
Perthane	10U	10U	10U	10U	10U	10U	10U		

Exceeds ERL

Exceeds ERM

Table 11. Comparison of Selected Chlordane Compounds Measured at LCE3, LCE5 and LCE6 In 1994, 2003 and 2009.

SITE	ANALYTE	1994*	2003	2009
LCE3	Chlordane-alpha		6	1.6
	Chlordane-gamma		6	1.9
	Total Chlordane		**12**	**3.5**
LCE5	Chlordane-alpha		0.7	6.5
	Chlordane-gamma		1	8.5
	Total Chlordane		**1.7**	**15**
LCE6	Chlordane-alpha	2.4	1.5	6
	Chlordane-gamma	3.3	1.7	12.2
	Total Chlordane	**5.7**	**3.2**	**18.2**

*Data from this year was sampled in triplicate. Values presented in the table represent an average of the three sample results.

Table 12. Comparison of DDT Compounds Measured at LCE3, LCE5 and LCE6 In 1994, 2003 and 2009.

SITE	ANALYTE	1994*	2003	2009
LCE3	4,4'-DDD		21.6	4.2
	4,4'-DDE		17	3.9
	4,4'-DDT		ND	2.1
	2,4'-DDD		ND	ND
	2,4'-DDE		ND	ND
	2,4'-DDT		ND	ND
	Total DDT		**38.6**	**10.2**
LCE5	4,4'-DDD		2.8	ND
	4,4'-DDE		3.7	23.8
	4,4'-DDT		ND	ND
	2,4'-DDD		ND	ND
	2,4'-DDE		ND	ND
	2,4'-DDT		ND	ND
	Total DDT		**6.5**	**23.8**
LCE6	4,4'-DDD	3.5	8	19
	4,4'-DDE	16.4	8.9	ND
	4,4'-DDT	ND	ND	ND
	2,4'-DDD	1.4	ND	ND
	2,4'-DDE	1.6	ND	ND
	2,4'-DDT	ND	ND	ND
	Total DDT	**22.9**	**16.9**	**19**

*Data from this year was sampled in triplicate. Values presented in the table represent an average of the three sample results.

TRACE METALS

Copper, lead and zinc are considered to be the primary metals of concern in the Los Cerritos Estuary since the freshwater portion of the watershed is listed for these metals and there is some concern that loads of particulate metals could impact the quality of sediment in the Estuary. The results of the sediment survey (Table 11) indicate that none of the metals were highly elevated at any station. ERMs were not exceeded for any of the metals analyzed. ERLs were exceeded for copper, lead, nickel, silver and zinc at LCE5 and LCE 6 in the lower portion of the Estuary. ERLs were also exceeded for arsenic, copper and nickel at LCE1, however, the lack of depositional conditions at this site suggest that these metals are associated primarily with the hard clays that form the channel at this location.

The field duplicate taken at LCE2 showed evidence of extreme variability for cadmium, copper, lead, silver, tin and zinc, while results for metals such as aluminum, iron, manganese, titanium and vanadium (which are all typically abundant crustal elements) were remarkably similar. This suggests that the high energy environment of the upper portion of the Estuary may be very heterogeneous with respect to metals with significant anthropogenic sources.

Three of the survey sites, LCE3, LCE5, and LCE6, were previously sampled in 2003 as part of the Bight '03 survey. Figure 5 provides a comparison of the copper, lead and zinc concentrations measured in the 2009 survey with those from 2003. Copper and zinc concentrations have remained remarkably similar between surveys at all three sites. Concentrations of zinc, however, appear to have declined substantially at all sites but most significantly at LCE3 (Bight '03 station 4636).

Concentrations of nickel in sediments from LCE3, LCE5 and LCE6 exceeded the ERL during the current survey (Table 11) but were typically lower than reported in the Bight '03 survey from this area (29 to 48 mg/Kg dry weight). In addition, data used to support the ERL/ERM values are not considered as robust as the data set for other metals.

Similarly, silver exceeded the ERL at both LCE5 and LCE6 during the current study (Table 11). Concentrations of silver measured in sediments during the Bight '03 Survey exceeded the ERL at stations LCE3 (4636) and LCE6 (4456) but not at LCE5 (4118). Despite the spatial variability, there have been no dramatic changes in general levels of silver since 2003. The presence of silver at elevated levels such as encountered in this region can be an indication of anthropogenic sources.

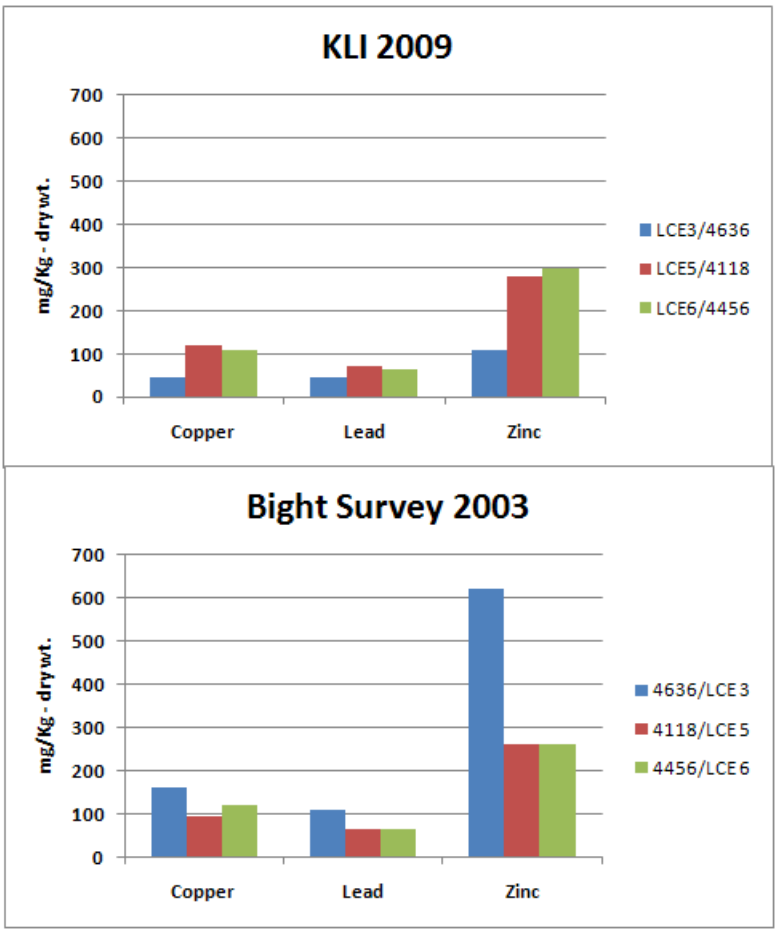


Figure 4. **Comparison of Three Metals in Sediments Sampled During both the Bight '03 Survey and the 2009 Los Cerritos Channel Estuary Sediment Survey.**

Table 13. Trace Metals in Surficial Sediments from each Los Cerritos Estuary Site.

	SAMPLING SITES								
	LCE1	LCE2	LCE2 FD (LCE7)	LCE3	LCE4	LCE5	LCE6	ERL	ERM
TRACE METALS									
Aluminum (Al)	34790	4532	4391	14830	7270	18960	18220		
Antimony (Sb)	0.57	0.35	0.43	0.61	0.56	0.93	1.01		
Arsenic (As)	10.8	2.3	2.3	7.4	2.5	7.9	7.1	8.2	70
Barium (Ba)	323	51	46	157	56	144	154		
Beryllium (Be)	1.14	0.15	0.13	0.55	0.22	0.65	0.63		
Cadmium (Cd)	0.26	0.36	1.99	0.31	0.24	0.92	1.1	1.2	9.6
Chromium (Cr)	54.0	10.2	16.2	28.9	14.7	45.4	42.8	141	370
Cobalt (Co)	20.8	3.3	3.5	10.9	4.6	11.4	11.2		
Copper (Cu)	59.3	18.7	32.4	44.4	25.5	119.4	109.3	34	270
Iron (Fe)	41930	7302	7962	23420	12260	28680	28170		
Lead (Pb)	13.3	17.7	41.7	44.9	21.4	71.1	62.8	46.7	218
Manganese (Mn)	667	108	111	248	134	297	295		
Molybdenum (Mo)	0.6	1.0	1.4	7.0	2.8	5.0	4.6		
Nickel (Ni)	37.3	7.3	8.4	21.2	10.2	27.7	27.7	20.9	51.6
Selenium (Se)	0.095	0.055	0.052	0.164	0.084	0.36	0.32		
Silver (Ag)	0.57	0.39	0.93	0.69	0.44	1.27	1.33	1.0	3.7
Strontium (Sr)	135	101	72	83	34	119	144		
Thallium (Tl)	0.23	0.06	0.05	0.15	0.07	0.31	0.29		
Tin (Sn)	1.40	1.10	2.71	1.49	1.26	4.51	4.46		
Titanium (Ti)	2001	361	365	1049	622	1384	1353		
Vanadium (V)	93.2	16.3	15.6	46.5	26.8	64.7	63.2		
Zinc (Zn)	99	131	237	109	84	279	300	150	410

Exceeds ERL

Exceeds ERM

SUMMARY AND CONCLUSIONS

Much of the upper Los Cerritos Estuary between Atherton and Seventh St. was found to be actively scoured by tidal currents and storm events. The 1.3 miles of the estuary extending from the Atherton St. Bridge to the LCE4 sampling location had similar bottom characteristics. All four sites (LCE1-4) along this portion of the Estuary were characterized by a hard, dry clay layer that was difficult to penetrate. At LCE1 there was no evidence of depositional sediments and the bottom consisted of a hard, dry clay covered by a thin algal mat. Sampling sites LCE2, LCE3, and LCE4 showed evidence of thin layers of sediment over the top of the clay layer. A depositional layer was first evident at LCE2 but the layer of unconsolidated sediment was thin (approximately 5 cm) and relatively sandy. The thickness of the depositional layer increased slightly at LCE3 and LCE4 and showed evidence of increasing levels of finer grained material.

The physical characteristics of the sediment at both the LCE5 and LCE6 sampling sites were substantially different. The hard clay layer underlying the upper 1.3 miles of the Estuary was not evident at these sites. The sediment at both these sites was less than 50% solids, compared to sediments from the upper portion of the estuary (LCE1 through LCE4) that contained 68 - 83% solids.

Chlordane compounds remain an issue of concern in sediments of the Los Cerritos Estuary. Concentrations were at or near the ERM level at three of the four sites sampled in the upper portion of the Estuary. Only traces of two chlordane compounds, chlordane-gamma and trans-nonachlor, were detected at the LCE1 sampling site. This was clearly due to the fact that tidal currents and storm flows are preventing the accumulation of any substantial quantities of sediment. Chlordane compounds measured in sediments from the lower portion of the estuary were over four times the ERM and concentrations at both sites far exceeded previous survey results in 1994 and 2003.

DDT compounds followed similar distributional patterns, although concentrations never exceeded ERMs. Concentrations in sediments from the four sites in the upper Los Cerritos Estuary ranged from below detection limits at LCE1 to 10.2 ng/g at LCE3. Concentrations of DDT were again highest at LCE5 (23.8 ng/g) and LCE6 (19 ng/g).

Trace metals were also moderately elevated at LCE5 and LCE6 in the lower portion of the Estuary. Five metals exceeded the ERLs at these sites but none exceeded ERM benchmarks. ERLs were exceeded by two to three metals at most other survey sites. There is little evidence of substantive changes in concentrations of metals at LCE5 and LCE6 since they were last sampled in the Bight ’03 Survey.

Overall, the two survey sites in the lower portion of the Los Cerritos Channel Estuary showed the highest level of contamination. Storm events, which transport thousands of tons of sediment every year, are the most likely source of contamination, as organochlorine pesticides are particularly associated with suspended sediment. In addition, Marine Stadium and Alamitos Bay cannot entirely be eliminated as potential sources, due to the flow reversals in this portion of the estuary caused by the pumping of cooling water for AES’s Alamitos power plant.

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